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Good morning, everybody, and welcome to the March 2025 *Eye on the Market* podcast. This is the one is entitled "Heliocentrism." This is our podcast for the 15th annual *Eye on the Market* energy paper. And I want to start with a picture that I took of the red crab migration in Christmas Island, Australia, a few years ago. Millions and millions of crabs traverse the island every year.

Nobody knows exactly why, but it's a kind of remarkable thing to see. And the whole island is overrun with these migrating red crabs. And I'm showing this because I started writing this energy paper 15 years ago. Also, for reasons that are unexplained, I just decided to do it. So like a red crab every year, I go through this three- to four-month migration process of researching energy and talking about energy and writing about energy.

And so, I enjoy it. Hopefully as much as the red crabs do. And this, this year's piece is called "Heliocentrism." Heliocentrism refers to the belief for few hundred years ago, which finally emerged that the world does, that the earth revolves around the sun rather than the sun revolving around the Earth. And the reason I picked it as a topic is because there's a lot of people out there that are now so focused on the growth and solar power that they believe that solar power typically bolted on with some energy storage can represent the dominant share of where we get our energy from.

So let me just show you a few pictures, and then we can explore that thesis. One thing's for sure, global solar capacity, both utility scale and rooftop, is exploding. And if the forecasts from several places are correct, you can see here on the first chart that we're going to get another doubling or tripling of global solar capacity over the next just two to three years.

And if, if we think about it as a percentage of all the capacity that's being installed, it's already about two-thirds of all new generation capacity, and expected to reach about three-quarters of all generation capacity for the rest of the decade. So it's kind of a remarkable transition to see solar advancing this much and this quickly.

Okay, this now, this is the part of the podcast when the buts start. So first solar, based on all the installations that exist to date, has a capacity factor of 15 to 20% around, in most places around the world, not all, but in most places where it's been installed. So if we translate that into shares of electricity generation, solar accounts for around 6% of global electricity generation.

That, that number probably doubles over the next three years, which is impressive. But as we've talked about in this energy paper, endlessly, electricity is roughly only a third of all the energy that gets consumed. A lot of countries are electrifying at a very slow pace. So if we

translate this solar power into the share of final energy consumption around the world, it's only 2%, probably growing to 4 to 5% by the end of the decade.

So while that's impressive growth from a low base, we obviously need to be more focused on the other 95% of where we're going to get our final energy consumption from, and rather than just the solar on its own. So impressive growth in solar power, declining costs, declining cost of storage, but some of the narratives about heliocentrism have gotten a little carried away.

And because some of those, some of those people don't believe that we need to either invest in or, either existing or new gas capacity, for example, which I think is a difficult argument to make. So one way to think about this and why it's so important to understand the rest of the ecosystem is modern prosperity, in almost all places where it thrives, revolves around certain kinds of industrial products: chemicals, iron, steel, cement, food, paper, machinery, metals, textiles, and other kinds of industrial products, glass, rubber, things like that.

Those are the components of modern prosperity. It's very difficult to find a prosperous country that doesn't have those things in terms of either producing them or buying them from people that do. And if we look at the energy of that is used to create those industrial pillars, 80, roughly 80% of them, of the energy of the input energy is from fossil fuels, whether it's oil, natural gas or coal directly, or the coal or natural gas that's used to make electricity that is then used to produce those things.

So as things stand now, modern prosperity is highly reliant on fossil fuels, as we all know. But it's interesting to kind of see the numbers and see the graphs laid out like this, so that you can appreciate just how the whole, the whole piece fits together. And so it's while we should be trying to decarbonize as much as we possibly can, we have to be realistic about the pace at which this can be done.

And one of the, one of the, the subheads of this year's piece is the objects may be further away than they appear. It's the opposite of the thing that you see in your rearview mirror. And so here's a chart that we've shown several times every year. The renewable share of electricity generation goes up in the U.S. and in many other countries.

Right. So every year the renewable electricity generation is going up, but the share of electricity used in final energy consumption isn't budging in the U.S. China is making a lot of progress. A few other countries are making some progress, but in a lot more countries are like the U.S. than like China in terms of somewhat stagnant or very slow growth in electrification of energy consumption.

So, and so that's a challenge in terms of decarbonization. And the most important chart, I think, in this year's energy piece is this one, and I call it the Scorpion Bowl chart. If anybody remembers, the, the scorpion balls were these things that you could get at the Hong Kong

Bar and Harvard Square, and they had, you know, tequila and rum and gin, and all sorts of things in them.

I call this the Scorpion Bowl chart because it's, it also has everything in it. So when we produce a chart that says the renewable share of final energy consumption, it's got everything. It's got wind and solar displacing coal, it's got lithium ion battery storage, rooftop solar. It reflects electrification of cars, trucks, busses, motorcycles, electrolytic green hydrogen, carbon capture, decarbonized production of steel and ammonia cement.

It includes electric heat pumps displacing residential, commercial, industrial furnaces and boilers. Biofuels. Biomass. Deep geo, critical G super critical, geothermal, synthetic fuels, hydro, etc., etc. So everything's in here. And how's it going? Well, after about $9 trillion in investment globally since 2010, what we have here is a linear transition in Europe at this, the shares growing at about half a percent a year.

In the U.S., it's growing about 8.3% a year. So there's progress being made. And for people that say that there's no progress at all, they're wrong. But the progress is very slow, which results in a lot of important discussions about the other kind of energy systems that you need to simultaneously be investing in in order to maintain your prosperity.

So for me, this chart is very important because, it's important to understand the pace at which these things can change. A lot of the stuff I read on green tech media sites and things like that, and from the Rocky Mountain Institute are constantly talking about S curves and accelerating geometric adoption of renewables. When you look at it from this perspective, it's not happening at that speed.

Now, there can be industrial transitions that occur more quickly. One example is this very rapid, energy-saving steel transition that took place in the 60s and 70s. And within around 20 years, almost all of the global steel production processes shifted from something called open heart furnaces to basic oxygen furnaces. Why did, but why did this happen so quickly?

You can't just look at this chart and say, okay, sometimes industrial transitions can be rapid. It happened because the new technology cut steel production times to a tenth of what they used to be, allowing for 80 to 90% savings in energy costs. So when you have a transition that can pay for itself like this, it can happen rapidly.

But that's not the case with the transition that we're currently experiencing now. Just a few more exhibits and, and then I'll let you go. I mean, the piece is 50, 54 pages. There's a lot in there. And I would encourage anybody who wants to learn about energy, start with the executive summary, which is seven pages, and then pick the different topics that you find interesting.

But just a few charts here. It's hard to electrify a country when the country itself is having so much trouble building transmission lines, and we've gone from about 4,000 miles of transmission lines being added each year to less than a thousand over the last couple of years. So this is going in the opposite direction of electrification.

The other thing to remember too, is electricity per unit of energy costs a lot more than natural gas. So for people that are focused on electrification of heat by industrial or residential or commercial users, yes, you can swap out your furnace or boiler for an electric heat pump that operates much more efficiently and uses less energy, but the energy that it uses can be anywhere from two to five times more expensive than the energy that you used to use because electricity is a lot more expensive than gas.

Not just in the United States, but in most countries. So that's another important impediment to electrification. And by the way, just for good measure, if you looked at all of the 47 categories in the producer price basket in the United States, practically the highest rate of inflation over the last few years has been transformers and power regulators.

And we're barely on this electrification journey. Right, so there's a lot of supply chain questions related to the equipment. And do we have enough electrical engineers, etc., etc., to implement a lot of these electrification visions that people will talk about now, the, the people that run the independent system operators in the United States disagree with the Helios interests.

Remember, the Helios interests we've defined as the people that believe that you just need more solar, more storage, and you don't need to invest in natural gas. The, the people that run the independent system, operators are screaming from the other side, like, please pay attention. Our reserve buffers during peak summer demand are shrinking because as we retire baseload power and replace it with renewables, we're getting more and more close to the point where we might have some kind of brownout situation, and the Midwest, the Northwest, California, New England, are places where you're seeing the most acute squeeze by the end of this decade.

Now, there's a lot of discussion about data centers. I'm not going to get too hung up on it here. I just want to show you a couple of different forecasts that are out there. If you add up data centers, electrification of vehicles and electrification of heat through heat pumps, you can, you can sense some people are penciling in a combination of a 20% increase by 2030 and electricity demand, or as low as 7%, but it's probably going to go up.

What's the important context? The important context is about electricity demand in the United States has been flat for around 20 years, but for the 20 years before that, the United States was more than capable of adding a lot of electricity generation capacity. The difference was at the time, those were large natural gas and nuclear plants that were being added rather than today.

Smaller renewables facilities. I also want to remind you about this green dotted line, for all the people that are really hung up on the data center issue. In 2007, the EIA made a projection of U.S. electricity demand going up a ton, and since then, actual electricity advanced, but flat. There are times when people don't appreciate increased efficiencies, and how that can sometimes offset increased demand and population growth.

I'm not going to spend too much time focused on the Trump policies. We have a couple of pages in the piece on what those energy policies are. But at the core of them, it's important to understand that the U.S. has achieved energy independence for the first time in 40 years, and unlike China and unlike Russia. And this chart here looks at the imports of net imports of oil, gas and coal, and common energy terms.

And this administration is extremely focused on energy policy, which is paying very close attention, attention to energy independence and national security. And obviously those priorities have, have shifted a lot versus the prior administration. And it's important to understand why. And this, this chart helps explain that. And I'm just going to close, I'm going to close this podcast by showing you a chart on the performance of renewables versus traditional energy.

So this looks at the performance of a composite of different renewable indices compared to traditional oil, gas and pipeline investing. The renewables crushed everything else in 2020 during the free money period from the Fed, and has been getting absolutely decimated ever since, and somewhere around, roughly around a 40%, underperformance since the beginning of this chart.

And I wish sometimes people would then pay more attention to the fundamentals behind the energy things they invest in. So I want to show you just a couple of things on sustainable aviation fuels, and then we'll close. This spaghetti chart gets people very excited because when they see the individual pieces of this on a term sheet or in a in a green energy blog, or in a YouTube video, they get all excited about the ability to create sustainable jet fuel.

And of course, who wouldn't want sustainable jet fuel to replace traditional jet? According to this diagram, there's lots of different ways using food oils, corn, cellulosic biomass. Or you can use electrolysis. There's a lot of different pathways through which you can create sustainable aviation fuel. The problem is they're all really expensive, and, and, and then a lot of them have an energy deficit.

I, one of the things that we discuss in here is that one of these, one of these pathways, if people were just paying attention, the thermodynamics are clear. It takes 150 megajoules of energy to go into the thing, and you get 50 megajoules of energy out of the thing. So there aren't too many successful businesses that our clients run that have a negative energy deficit like that.

And so I just think that people should pay more attention to that kind of thing. The renewable jet fuel cost estimates across the board, no matter how you do it, are much higher than traditional jet fuel estimates, which is why so many of the biofuel companies have been getting crushed because once their processing costs meet the light of day, investors don't like them quite so much.

Anyway, the, our 15th annual energy paper starts with an executive summary on heliocentrism and, and solar power and the speed of the transition. We have some comments from forklifts, mill and a lot of charts on how the planet is changing. We have a long section with 70 essential charts on the energy transition that we update every year, a section on Trump's energy policies and how the pendulum is swinging again. We have a section on the high cost of European decarbonization, Europe as the world's transition leader. But it's also paying the highest price for that decarbonization. We discuss the nuclear renaissance of interest in nuclear that's happening in the OECD. We introduce our new grid optimization model to understand how you can deeply decarbonize U.S. grids and how much it would cost. There's an important section on the LA fires. Climate change is an important part of understanding why it took place with respect to wind and rain and drought.

But that's not the whole story, particularly when you look at the breadth and depth of the damages. There's a lot of political issues as well. That's important to understand. Again, we have a section on renewable jet fuel. We look at methane tracking, from U.S. basins and how satellites are helping on that effort. We, yet another section on the disintegrating prospects for the hydrogen economy.

An important discussion on superconductivity. And then a brief review of topics that we might get into detail on next year. So that's the end of this podcast. Please enjoy the energy piece. And thank you for listening, and look forward to connecting with you in April, probably on healthcare. Thank you. That is, unless I get either measles or polio. Bye.

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